PNM San Juan Generating Station
BART Analysis of Nalco Mobotec NO_x Control Technologies
August 29, 2008

Introduction

In the June 18, 2008 meeting between the Public Service Company of New Mexico (PNM), Black & Veatch (B&V), and the New Mexico Environment Department – Air Quality Bureau (NMED), the NMED requested additional analyses be performed for the Nalco Mobotec NO_x control technologies. Specifically, the NMED requested additional consideration and modeling of the ROFA with Rotamix, Rotamix, and ROFA NO_x control technologies.

As described in the June 6, 2007 BART application document and in PNM's March 31, 2008 response to NMED questions, the ROFA technology is a type of overfire air (OFA) system, and the Rotamix technology is a version of SNCR control technology. The NMED requested that ROFA and Rotamix be analyzed separately from other LNB/OFA technology and SNCR, respectively.

Part 1 - Engineering Impact Analysis

At the request of the NMED, an engineering impact analysis was performed for the Nalco Mobotec NO_x control technologies. The results of that impact analysis are shown in Attachment 1. Table 7-1 in Attachment 1 is a modification to the Table 7-1 found in PNM's original BART submittal of June 6, 2007 and also the update submitted on May 30, 2008 to include SNCR. The table has been updated to include the engineering impact of the Nalco Mobotec NO_x control technologies. In addition to Table 7-1, Attachment 1 also includes the least cost curves for all NO_x control technologies evaluated for BART, detailed cost tables for installing Nalco Mobotec NO_x control technologies, cost development notes providing the basis for the ROFA cost estimates, and design concept definitions for each Nalco Mobotec technology.

In the response submitted to the NMED on March 31, 2008, a technical evaluation of the Nalco Mobotec NO_x control technologies was performed. The evaluation performed forms the basis of the engineering impact analysis for this supplemental BART analysis.

The BART analysis is based on the demonstrated experience of the Nalco Mobotec technologies. There is one installation of ROFA in units above 300 MW. This installation is for a confidential Northeast client (570 MW). Also, there is one operating installation of Rotamix in units above 300 MW; Sutton Station Unit 3 (424 MW). It should also be noted that the ROFA and Rotamix applications over 300 MWs both combust different fuels than SJGS. The Boswell Unit 4 (565 MW) is currently in the process of installing Rotamix, but to B&V's knowledge, the Rotamix system is not in operation yet. It should be noted that the application of Rotamix at Sutton produces higher emissions (lb/MBtu) than the Nalco Mobotec budgetary quote for PNM. There are no units greater than 300 MW in operation with both the ROFA and Rotamix technologies. Nalco Mobotec does have units with ROFA and Rotomix technologies under the 300 MW size, but these units are significantly smaller than the SJGS units and were not considered representative for this discussion.

In the engineering impact analysis, the cost estimates include contingencies to retrofit the ROFA fan to the existing site and the additional auxiliary energy consumption of these fans used to impart kinetic energy to the overfire air system to promote turbulent mixing during combustion. Due to the large additional amount of kinetic energy required for the rotating overfire air system, the auxiliary energy consumed by the ROFA fans is significantly higher than the LNB/OFA system currently installed to meet consent decree requirements.

At NMED's request, the control effectiveness presented in this supplemental BART analysis document for the ROFA, Rotamix, and ROFA with Rotamix technologies are the values from Nalco Mobotec's quotation. The ROFA technologies are based on operating the furnace at a lower burner stoichiometric ratio (BSR) of 0.84 than the currently designed value of 0.90.

Control Effectiveness of Nalco Mobotec Technologies	
Technology	Control Effectiveness (lb/MBtu)
ROFA with Rotamix	0.20
Rotamix	0.23
ROFA	0.26

Also included in the updated Table 7-1 are the cost effectiveness evaluations previously completed and submitted for other NO_x control technologies. The cost effectiveness values are for additional NO_x removal from the consent decree level. As stated previously, this analysis of the Nalco Mobotec technologies was done at the request of the NMED. B&V and PNM do not agree that Nalco Mobotec's offerings should be differentiated from the other vendors that supply overfire air systems and selective non-catalytic reduction systems.

Nalco Mobotec has no specific documented operating experience with the SJGS coal. The fuel burned at SJGS is unique. It does not easily fit into either a bituminous or sub-bituminous fuel category.

As previously mentioned, the new low NO_x burners, which were installed for the consent decree would most likely need to be modified to optimize NO_x performance with the ROFA technology. On August 15, 2008, B&V had a telephone conversation with Nalco Mobotec to better understand how their technology works. In this conversation, Nalco Mobotec stated that their technology can be operated at a lower boiler stoichiometric ratio, in part, because of the changes that they would likely make to the new low NO_x burners. The burner modifications will, in effect, detune the new state-of-the-art B&W low NO_x burners to reduce the NO_x reduction performance by the burner. These changes would consist of physically modifying the burners to improve mixing. This work is typically performed by external consultants hired by Nalco Mobotec to re-design the burner systems. Nalco Mobotec states that this improved mixing will reduce the potential for corrosion and temperature imbalance. This increase in turbulence and mixing at the burner in most cases results in higher flame temperature and more rapid combustion close to the burner. The result would be expected to be less unburned carbon and less potential for flame impingement on the opposite boiler walls which would reduce the potential for fireside waterwall corrosion from overheating and flame impingement. Without these modifications, the previously discussed potential impacts of operating at this lower BSR may include corrosion due to the reducing environment in the boiler and impacts to the steam temperatures due to changing the location of the fireball. It should also be noted that even with the burner modifications, B&V continues to be concerned about the potential for increased slagging as well as the unproven nature of the Nalco Mobotec technology with the SJGS coal and units in this size range.

The control effectiveness used as the evaluation basis in this supplemental BART analysis is dependent on successfully addressing all of these concerns to avoid any negative impacts to the SJGS plant operations and availability rate. Meanwhile, other NO_x control technologies (LNB with OFA) are installed or being installed that have all these technical concerns already addressed.

For Rotamix, there is only one unit with Rotamix above 300 MW. This unit does not produce the low level of NO_x quoted by Nalco Mobotec for PNM. In comparison, Fuel Tech has 17 commercial SNCR only (not in combination with other Fuel Tech technologies) installations and 3 demonstration installations on units greater than 300 MW. Fuel Tech has significantly more experience with SNCR on units in the size range of SJGS. Therefore, B&V and PNM have greater confidence in the performance guarantee quoted by Fuel Tech. B&V and PNM are not comfortable with the technology risk that PNM would incur if a permit limit was applied to the SJGS that was based on the quote received from Nalco Mobotec. Furthermore, there is not a significant difference between the Fuel Tech quotation and the Nalco Mobotec quotation to warrant the risk that PNM would incur.

Lastly, for the combination of ROFA with Rotamix, the lower control effectiveness value proposed by Nalco Mobotec in comparison to the LNB/OFA with SNCR approach submitted in the May 30, 2008 update is due to the a lower starting (uncontrolled) NO_x level. With the ROFA technology, uncontrolled NO_x for Rotamix is 0.26 lb/MBtu. While for LNB/OFA, the uncontrolled NO_x for SNCR is 0.30 lb/MBtu. Both Rotamix and SNCR then reduces NO_x by approximately 20% to 0.20 lb/MBtu and 0.24 lb/MBtu, respectively. Therefore, it is observed that the incremental NO_x reduction in terms of percentage is very similar between the ROFA with Rotamix and the LNB/OFA with SNCR combinations.

Part 2 – Visibility Analysis

Subsequent to the June 6, 2007 submittal, PNM further investigated additional refinements to the BART CALPUFF air dispersion modeling analyses which included nitrate repartitioning and more realistic ammonia background concentrations based on monitored values at several western Class I areas. These additional modeling options are considered more realistic and therefore will again form the basis of this analysis.

To date, PNM has previously submitted four BART modeling analyses in addition to the Wet ESP analysis being submitted separately but coincident with this analysis. To clarify the contents of these analyses, as well as for this submittal, a summary of each has been provided:

June 6, 2007

Modeling analysis were performed to provide SJGS plant-wide regional haze (visibility) impacts at 16 Class I areas. The analyses were based on a constant 1 ppb background ammonia concentration and no nitrate repartitioning. The NO_x control technologies analyzed were the Selective Catalytic Reduction (SCR) and SNCR/SCR Hybrid.

November 6, 2007

Modeling analysis were performed to provide SJGS plant-wide regional haze (visibility) impacts at 16 Class I areas. The analysis was based on refinements which included using the nitrate repartitioning methodology and monthly variable background ammonia concentrations. Again, the NO_x control technologies analyzed were the SCR and SNCR/SCR Hybrid.

March 31, 2008

Two main modeling analyses were performed to provide SJGS plant-wide and unit specific regional haze (visibility) impacts at 16 Class I areas for the SCR NO_x control technology only. One of the analyses, believed to be the more representative of ammonia chemistry of the area, was based on the November 6, 2007 refinements which included using the nitrate repartitioning methodology and monthly variable background ammonia concentrations. The other analyses included nitrate repartitioning and a constant background ammonia concentration as requested by the NMED.

May 30, 2008

Two modeling analyses were performed to provide SJGS plant-wide and unit specific regional haze (visibility) impacts at 16 Class I areas for the SNCR NO_x control technology only. Similar to the March 31, 2008 analyses, one of the analyses was based on the November 6, 2007 refinements which included using the nitrate repartitioning methodology and monthly variable background ammonia concentrations. The other analyses included nitrate repartitioning and a constant background ammonia concentration. It should be noted that all vendors of SNCR (including Fuel Tech and Nalco Mobotec) have been modeled together as one technology called SNCR. This is the same approach that is used for modeling SCR control technology, where all vendors are modeled generically as SCR.

August 29, 2008

Three modeling analyses were performed to provide SJGS plant-wide and unit specific regional haze (visibility) impacts at 16 Class I areas for the ROFA with Rotamix, Rotamix, and ROFA NO_x and WESP PM control technologies (the NO_x and PM analyses were submitted separately). Similar to the May 30, 2008 analyses, these analyses were also based on the November 6, 2007 refinements which included using the nitrate repartitioning methodology and monthly variable background ammonia concentrations.

The modeling refinements contained in this submittal using nitrate repartitioning and the variable ammonia background as well as the previous November 2007, March 2008, and May 30, 2008 submittals supersedes the original June 2007 BART modeling analyses as PNM believes these analyses are more representative of regional conditions in the modeling domain, as well as, allow for a more representative visibility analysis.

Information pertinent to these two refinements has been included in detail in the previous four submittals. Furthermore, at the June 18, 2008 meeting NMED indicated that based on a current ammonia monitoring study conducted by Mark E. Sather of EPA Region VI, the previous analyses provided utilizing the variable ammonia were representative of the surrounding background. Therefore, no other analyses were performed using nitrate repartitioning and constant background ammonia.

Visibility Summary

Based on the refinements methodology consisting of representative background ammonia concentrations and nitrate repartitioning, revised CALPUFF visibility modeling was performed for five cases; pre-consent decree, consent decree (which represents SJGS's BART baseline scenario), ROFA with Rotamix, Rotamix, and ROFA NO_x control technology scenarios. The modeling summarized in this report is for the SJGS on a plant-wide basis and for each of the four SJGS units on an individual unit basis. It is important to note that all other modeling options as described in the BART application were unchanged. For simplicity, the following results discuss the differences between the consent decree scenario and the NO_x control technology scenarios. The stack outlet conditions for the NO_x control technology scenarios are included in Attachment 2 and the visibility modeling results are contained in Attachment 3.

SJGS Facility Visibility Summary with Nitrate Repartitioning and Variable Ammonia

The results of the refined visibility modeling for the SJGS plant, assuming the same control technology is installed on all four units, are illustrated in Tables 1 through 6 of Attachment 3. These tables summarize the scenarios and the maximum visibility (deciview) impact seen at any of the 16 Class I areas at any time over the 2001 to 2003 period. The results of this analysis, using the aforementioned refinements, indicates a minimal improvement in visibility impact (less than 0.5 dv) at each of the 16 Class I areas when compared to the baseline (consent decree) scenario.

The maximum visibility (deciview) improvement seen at any of the 16 Class I areas at any time over the 2001 to 2003 period is illustrated in Table 6 for each scenario. The expected degree of visibility improvement for each control scenario for each unit (on a plant-wide basis) was determined by the difference in the maximum visibility improvement for each receptor at each of the sixteen Class I areas. Again, it is important to note that the control technology associated with the consent decree formulated the SJGS's baseline case, as well as the baseline case for the individual unit analyses described later. Additionally, the cost-effectiveness for the potential BART control technologies from the BART application were used to calculate visibility improvement cost-effectiveness in \$/deciview (\$/dv). Three major scenarios are shown in the visibility improvement cost effectiveness summary in Table 6 for each control technology:

- Pre-consent decree to consent decree.
- Consent decree to additional NO_x control technology alternative scenarios.
- Pre-consent decree to additional NO_x control technology alternative scenarios.

These maximum visibility improvements between the consent decree and the three NO_x control technology scenarios range from 0.04 dv to 0.34 dv of expected visibility improvement above the consent decree scenario. The visibility improvements for each of the Nalco Mobotec control technology options are summarized below:

- Facility improvements with ROFA/Rotamix range from 0.09 dv to 0.34 dv.
- Facility improvements with Rotamix range from 0.09 dv to 0.25 dv.
- Facility improvements with ROFA range from 0.04 dv to 0.21 dv.

The results indicate that adding additional NO_x control technology beyond the consent decree does not yield visibility improvement greater than 0.5 dv at any Class I area. In fact, as previously noted, the maximum visibility improvement at any of the 16 class I areas is only 0.34 dv.

Based on the visibility improvement modeled and the total annual cost evaluated in the impact analysis stage of the BART application document, the cost-effectiveness for visibility improvement (annual cost per improvement in visibility, \$/dv), was determined for SJGS over the aforementioned range of visibility improvement. The resulting cost for installation of Nalco Mobotec NO_x control technology for all four units ranges from \$464 million/dv to \$69 million/dv. The visibility improvements for each of the Nalco Mobotec control technology options are summarized below:

- ROFA/Rotamix range from \$369 million/dv to \$97 million/dv.
- Rotamix range from \$269 million/dv to \$69 million/dv.
- ROFA range from \$464 million/dv to \$82 million/dv.

Attachment 3 contains a SJGS plant-wide summary of the 98th percentile visibility impact for the three modeled technology scenarios (i.e., Pre-Consent Decree, Consent

Decree, ROFA/Rotamix, Rotamix, and ROFA scenarios), provides information on the number of days above 0.5 dv threshold, and indicates the contribution of each pollutant associated with the 98th percentile visibility impact for each class I area.

Unit Specific Visibility Summary with Nitrate Repartitioning and Variable Ammonia

The results of the refined visibility modeling for Unit 1, Unit 2, Unit 3, and Unit 4 are illustrated in Tables 7-12, 13-18, 19-24, and 25-30 of Attachment 3, respectively. These tables summarize the scenarios and the maximum visibility (deciview) impact seen at any of the 16 Class I areas at any time over the 2001 to 2003 period. Similar to results seen for the SJGS facility, the visibility impacts at Mesa Verde, in many cases, represent the maximum visibility impact at any of the 16 Class I areas. In addition, this analysis indicates a minimal improvement in visibility impact (less than 0.5 dv) at each of the 16 Class I areas when compared to the baseline (consent decree) scenario.

The maximum visibility (deciview) improvement seen at any of the 16 Class I areas at any time over the 2001 to 2003 period is illustrated in Tables 12, 18, 24, and 30. Again, the expected degree of visibility improvement for each control scenario for each unit was determined by the difference between the consent decree's maximum visibility improvement for each receptor at each of the sixteen Class I areas and the specific NO_x control technology scenario's maximum visibility improvement for each receptor at each of the sixteen Class areas. Furthermore, the same methodology previously described for the SJGS's cost-effectiveness in ($/dv) was used here for each unit.

These maximum visibility improvements between the consent decree and the NO_x control scenario for each unit are similar to that of the combined SJGS. The visibility improvements for each scenario are summarized below.

ROFA/Rotamix

- Unit 1 improvements range from 0.02 dv to 0.23 dv.
- Unit 2 improvements range from 0.02 dv to 0.23 dv
- Unit 3 improvements range from 0.05 dv to 0.24 dv
- Unit 4 improvements range from 0.04 dv to 0.24 dv

Rotamix

- Unit 1 improvements range from 0.02 dv to 0.17 dv.
- Unit 2 improvements range from 0.02 dv to 0.18 dv
- Unit 3 improvements range from 0.02 dv to 0.17 dv
- Unit 4 improvements range from 0.03 dv to 0.18 dv

ROFA

- Unit 1 improvements range from 0.01 dv to 0.11 dv.
- Unit 2 improvements range from 0.01 dv to 0.12 dv
- Unit 3 improvements range from 0.0 dv to 0.12 dv
- Unit 4 improvements range from 0.01 dv to 0.12 dv

The results again indicate that adding additional NO_x control technology beyond the consent decree consisting of ROFA/Rotamix, Rotamix, or ROFA does not yield visibility improvement greater than 0.5 dv at any Class I area. Based on the visibility improvement modeled and the total annual cost evaluated in the impact analysis stage of the BART application document, the cost-effectiveness for visibility improvement (annual cost per improvement in visibility, $/dv), was determined for each unit for each Class I area. The resulting cost for installation of additional control technology for each unit is summarized below.

ROFA/Rotamix

- Unit 1 cost range is $322 million/dv to $33 million/dv.
- Unit 2 cost range is $308 million/dv to $29 million/dv.
- Unit 3 cost range is $209 million/dv to $41 million/dv.
- Unit 4 cost range is $224 million/dv to $40 million/dv.

Rotamix

- Unit 1 cost range is $197 million/dv to $21 million/dv.
- Unit 2 cost range is $187 million/dv to $20 million/dv.
- Unit 3 cost range is $214 million/dv to $28 million/dv.
- Unit 4 cost range is $176 million/dv to $27 million/dv.

ROFA

- Unit 1 cost range is $432 million/dv to $30 million/dv.
- Unit 2 cost range is $384 million/dv to $29 million/dv.
- Unit 3 cost range is $1,281 million/dv[1] to $43 million/dv.
- Unit 4 cost range is $512 million/dv to $42 million/dv.

[1] The visibility improvement realized for Unit 3 is 0.004 dv but is illustrated in Attachment 3, Table 24 as 0.00 dv.

Attachment 3 also includes a unit specific summary of the 98th percentile visibility impact for the three modeled technology scenarios (i.e., Pre-Consent Decree, Consent Decree, ROFA/Rotamix, Rotamix, and ROFA scenarios), includes the number of days above 0.5 dv threshold, and indicates the contribution of each pollutant associated with the 98th percentile visibility impact for each class I area.

Additional Considerations

The minimal visibility improvements discussed in this document for the variable ammonia case do not merit the large capital expenditure required to install ROFA/Rotamix, Rotamix, or ROFA NO_x control technology. In addition to the high cost and minimal visibility improvements associated with these technologies, there are other important reasons that LNB, OFA and NN should be considered BART for the SJGS units. First, the LNB, OFA and NN systems are being installed to meet the consent decree are state-of-the-art combustion controls. State-of-the-art combustion controls comprising of LNB, OFA and NN technologies were used to form the basis for the BART presumptive limits for NO_x in the BART guidelines. Second, the ROFA NO_x control technology is a LNB/OFA technology in which SJGS already has installed or will soon be in the process of installing on their four generating units. Third, the visibility results imply that visibility is influenced more by the SJGS's sulfur emissions than by the reduction of NO_x. However, sulfur emissions are not subject to BART requirements because New Mexico participates in the WRAP emissions trading program.

Fourth, installation of SNCR, ROFA/Rotamix or Rotamix requires ammonia to reduce NO_x emissions. Specifically, in a SNCR system, urea is injected into the boiler and this will decompose into ammonia for the NO_x reduction process. Any unreacted ammonia passes through the boiler and out the stack as ammonia emissions or ammonia slip. This additional ammonia would then be available to add to the ammonia background concentration, chemically react to form nitrates and sulfates, and potentially further increase the visibility impacts at the Class I areas. The additional ammonia slip was not considered in this analysis.

Fifth, as described in Part 1, the Nalco Mobotec ROFA or ROFA/Rotamix system requires detuning of the new LNB systems coincident with the installation of the ROFA system. This causes a potential negative scenario if a forced outage occurs with the ROFA fan system. Without the ROFA fan to complete the combustion process, the detuned LNB, which has significantly higher NO_x emissions than the tuned LNB, will quite likely result in a forced outage of the unit to avoid exceedance of the NO_x emissions limit. This results in lost generation for PNM. This scenario may be avoided in a LNB/OFA system since the increase in NO_x emissions when the OFA system is out of service will be minimal when compared to the ROFA system.

Finally, PNM entered into a consent decree with the Grand Canyon Trust, Sierra Club, and NMED on March 10, 2005, to settle alleged violations of the Clean Air Act. For NO_x control, the settlement required installation of state-of-the-art NO_x combustion controls which was deemed to be new LNB with OFA and a NN system. All four units will have these controls installed by the spring of 2009. Due to the nature of the consent decree requiring the approval of and installation of state-of-the-art combustion controls to achieve a specific NO_x emission limit, detuning of this LNB system to increase NO_x emissions as part of the ROFA or ROFA/Rotamix may be prohibited without additional legal action. At a minimum, all parties identified in the consent decree may have to agree to the proposed modification should ROFA or ROFA/Rotamix be determined by NMED to be BART.

Conclusion

As noted in this document, PNM's further investigation of additional refinements to the June 2007 BART CALPUFF air dispersion modeling analyses to yield more realistic regional haze impacts was warranted. These analyses included nitrate repartitioning and more realistic ammonia background concentrations based on monitored values at several western Class I areas, as well as, the additional ammonia study being conducted by EPA in New Mexico. The conclusion of this study re-iterates and further supports the overall findings of the original June 2007, as well as, the three aforementioned additional submittals, that installation of additional NO_x control technology systems at the SJGS provide minimal visibility improvements and would require significant capital expenditure and modifications that will impact many areas of the plant including boiler draft systems, air heater performance, and ash handling. The results from the analyses further substantiate that the addition of ROFA/Rotamix, Rotamix, or ROFA NO_x control technology does not yield a benefit nor meet the intended goal of BART. Specifically, these analyses indicate:

- The addition of ROFA/Rotamix, Rotamix, or ROFA NO_x control technology on a plant-wide or individual unit basis shows less than a 0.5 dv improvement for all Class I areas including the four Class I areas located in New Mexico.
- Both the total annual costs evaluated and the cost-effectiveness ($/dv) are prohibitive given the minimal improvements realized.
- Although B&V has received additional clarifications from Nalco Mobotec on the ROFA technology, B&V and PNM continue to have concerns about the potential

for slag using the ROFA system, Nalco Mobotec's lack of experience with the fuel burned at SJGS, and Nalco Mobotec's minimal experience with units of a similar size to SJGS.

Therefore, as previously noted, given the minimal visibility improvement to the Class I areas in the BART analysis, the recommended NO_x BART control for SJGS is LNB, OFA, and a NN.

ATTACHMENTS 1 – 3

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